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Before the

FEDERAL COMMUNICATIONS COMMISSION

Washington, DC 20554

In the Matter of	)	
	)	
Guidelines for Evaluating the Environmental Effects of Radiofrequency Radiation	)	ET Docket 93-62

PETITION FOR RECONSIDERATION

Regarding First Memorandum Opinion and Order FCC 96-487

First Memorandum Opinion and Order FCC 96-487 was adopted by the Commission Dec. 23, 1996, released Dec. 24, 1996 and published, in summary form, in the Federal Register on Jan. 22, 1997. 47 CFR Chapter 1, Sec. 1.429(i) states that "Any order disposing of a Petition for Reconsideration which modifies rules adopted by the original order is, to the extent of such modification, subject to reconsideration in the same manner as the original order."

The Cellular Phone Taskforce, on the basis of the evidence previously submitted in Motions in this Docket, and evidence newly available, hereby petitions the Commission for reconsideration of the amended rules contained in the First Memorandum Opinion and Order. As stated in the Opposition to Paging Network's Petition for Reconsideration, and in the Reply to Comments of AT&T Wireless Services, Inc., the Cellular Phone Taskforce opposes extending the transition

period for compliance with the Final Rules adopted August 6, 1997, for the reasons stated in those Motions. The delay in implementation of the new regulations will allow the proliferation of an unlimited number of facilities authorized under part 15, subparts E and H of part 22, part 90, and part 94 during the coming year. This will, in particular, harm and discriminate against the electrosensitive, who are represented in this matter by the Cellular Phone Taskforce. The serious concerns of the Cellular Phone Taskforce and its constituency were not addressed in the First Memorandum Opinion and Order. The Commission merely stated that it does not concur with them.

Since the end of the Comment period in October, new evidence has come to light making our concerns much more urgent. First, a study was completed and published in November 1996 reviewing 70 years of research into the health effects of low level microwave radiation such as is being produced by all of the technology for which the August 6 Safety Guidelines were adopted. To our knowledge and belief, no such study has ever existed before. This study is called Microwaving Our Planet (Arthur Firstenberg, 1996, Cellular Phone Taskforce). One copy is enclosed for the Commission's convenience.

Second, in November 1996, personal communication services (PCS) technology was put into use over widespread areas of the United States for the first time. The results have been deadly. The first epidemiological studies are

now underway in New York City, indicating that thousands of people are suffering from radiation sickness, a disease entity which is described and documented in detail in Microwaving Our Planet. Some have fled their homes and their city.

It is urgent that effective rules be put in place that will prevent even more people from being made sick and homeless by deadly technology, and that such rules be enforced immediately and not delayed until September 1, 1997 or January 1, 1998.

Respectfully submitted,

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Original + 14 copies via U.S. mail, postage paid, to the Secretary of the Federal Communications Commission, 1919 M Street, NW, Room 222, Washington, DC 20554

MICROWAVING OUR PLANET

The Environmental Impact of the Wireless Revolution

by Arthur Firstenberg

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MICROWAVING OUR PLANET

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1 Microwaving Our Planet

Introduction

From Bill Gates' planned fleet of 924 satellites to the millions of ground based antennas being constructed throughout the world, our privacy is being invaded, our health undermined, our water polluted, endangered species threatened, the ozone layer destroyed, and our climate altered. The assault has already begun.

The purpose of this report is to give a general overview of the environmental threats associated with the wireless revolution, and an in-depth review of 70 years of research into the health hazards of microwaves.

The lack of an adequate review of the literature until now has led to the incorrect perception that the scientific evidence is contradictory and inconclusive. In fact the scientific evidence is consistent and overwhelming.

Satellite systems

In 1957 there were no artificial satellites in the sky above us. Today there are thousands. The list of countries that have launched satellites to date is huge: the United States, Canada, Mexico, Brazil, Argentina, France, Germany, Norway, Sweden, Spain, England, Russia, Turkey, China, Japan, Indonesia, India, Thailand, Korea, Malaysia, Australia, New Zealand, Tonga, the European Community, Eastern Europe, the Arab League, Pan-Asia, and Intelsat (125 nations). Multinational corporations are sending up fleets. Even small private entrepreneurs are filling up the heavens with smaller, cheaper hardware. Whether a cellular phone company wants to provide global service, or a rancher in Australia wants to know the whereabouts of his cows, satellite technology will do the trick.

Ground based towers

The existing network of ground based antenna systems is not good enough. The telecommunications industry says it will need 270,000 more facilities immediately just in the United States (Microwave News, May/June 1996, p. 10), and comparable numbers elsewhere in the world. These are going up on lampposts and apartment buildings in cities, and on fresh eyesores throughout the suburbs, countryside and wilderness.

In addition, satellite systems, which shine very weakly on us, need to communicate with their own network of powerful earth stations. These stations will proliferate along with the satellites.

Pandora's box

Until recently almost all radio transmitters have been fixed and their range limited. The addition of more broadcast channels and new types of communication devices did not change that. But with the advent of cellular technology, all limits have been lifted. Telephones are no longer just communicators but also transmitters, and they are mobile. Suddenly every human being is a potential source of radiation. Suddenly electronic communication is a human right. Suddenly fixed transmitters and satellites are being built to accommodate mobile human beings, rather than the other way around.

Electromagnetic pollution will no longer remain concentrated in population centers, nor will radio transmitters be confined any longer to non-residential zones. In the space of a year or two, unless the people put a stop to it, this form of pollution will be spread more or less evenly over every square inch of the world.

The power is small, but the reach is unlimited

There are among us today television towers that broadcast with a radiated power of 5 million watts. How much damage could the radiation from cellular equipment do by comparison? one might ask. Each antenna on a rooftop or tower generally emits less than 1000 watts, with 150 watts being the norm for lampposts and the sides of buildings.

The answer is surprising. If you live 10 miles from a 5 million watt television station, you will receive more radiation from a cellular antenna that is on a lamppost a block away than you will from that TV station. And by U.S. law, a 5 million watt TV station must be separated from other stations of similar frequency by a distance of at least 175 miles. Cellular transmitters are far less restricted: they can and will proliferate without limit. And they can and will increase their broadcast power if it is profitable to do so. The new legal limit is 3500 watts per channel per transmitting station, with no limit at all on the number of channels or the number of towers or the number of companies broadcasting in the same area.

Television signals also do not reach beyond line-of-sight from the tower, and are blocked by hills and buildings. The cellular transmitter is going to be right there where you are, anywhere on earth. You are no longer going to have the option of limiting your radiation exposure by living distant from antennas.

Health hazards

Microwave radiation is dangerous. As everyone knows, high levels will cook you. Low levels will also harm you in other ways.

Another type of radiation--that coming from electric power lines--has been much more in the news in previous

years. There is now a growing scientific consensus that the 60-cycle radiation from power lines is dangerous and can cause cancer, leukemia and other diseases. Fortunately the distribution of electricity is not yet wireless, and most of the earth's surface is still remote from high-tension wires.

Power line radiation (50 or 60 cycles per second, or hertz) is especially harmful because it is close to the frequency of brain waves. Microwave radiation is especially harmful because the wavelengths are smaller than our bodies. This radiation is therefore selectively absorbed by our bodies.

Table 1

	maximum frequency (Hz)	wavelength
power lines	60	3000 mi.
AM radio	1,600	600 ft.
short wave radio	30,000,000	30 ft.
FM radio	108,000,000	10 ft.
TV channels 2-13	216,000,000	5 ft.
TV channels 14-69	806,000,000	1 ft.
cellular phones	947,000,000	1 ft.
PCS	2,400,000,000	6 in.
satellites	50,000,000,000	¼ in.

Smaller waves are better absorbed by smaller body parts and smaller people (children).

Cellular transmitters are not only going to be more common than any transmitters have ever been before, they are also broadcasting at the most dangerous frequencies.

And this radiation will be doubly dangerous because all the new technology is going to be digital. Digital signals come in pulses, rather than continuously as is now the case, and pulsed radiation has been found by most investigators to be more injurious to living things at lower average levels of power than continuous radiation.

Government safety standards

In the United States the Federal Communications Commission has set standards of permissible irradiation of the general public. These standards are based on thermal hazards only, the assumption being that if microwaves aren't strong enough to cook you, they will do you no harm. For cellular telephone systems, exposure is permitted to power densities of 533 to 1000 uW/cm^2 (microwatts per square centimeter), depending on the frequency. These standards are at least ten million times the level which probably still exists over most of the surface of the earth, and at least ten billion times the level of microwaves we receive naturally from the sun and stars. They are also at least two hundred thousand times greater than what even most city residents have been exposed to until very recently (Tell and Mantiply 1980, Solon 1979, Zaret 1974, Szmigielski and Gil 1989).

Table 2: Exposure levels (uW/cm^2)

average stellar signal	.000000000000000000000001
cosmic radiation, 10 MHz	.000000000000000008
from a quiet sun, all freq.	.0000000001
from one cellular satellite	.0000001
in Tottenville, N.Y.C. 1978	.000068
average New York City 1979	.002
300 ft. from a cellular tower	5.0
in Empire State Building 1978	32.5
in Sears Tower 1978	65.7
F.C.C. Safety Standard 1996	1000.0

We can reasonable expect the radiation levels over most of the habitable parts of the earth to increase 1000-fold just as a beginning result of the current cellular expansion. How high those levels eventually will go is anybody's guess.

The danger, even if we didn't have epidemiological studies, is evident. We cannot expect to increase the irradiation of the entire earth 1000-fold or more virtually overnight without health effects and without massive biological consequences. Indeed this technology is more invasive than virtually any other and has the potential of causing worldwide catastrophe.

Review of the literature

The scientific literature is full of thousands of studies of the health effects of microwaves at power levels of 1-10 mW/cm^2. I will not review those here. Supposedly those levels of exposure are not enough to cause heating of the body, yet the defenders of the 1 mW/cm^2 (1000 uW/cm^2) safety standard dismiss any effects shown at those levels as heating effects. The absurdity of their position seems to escape them. But I will bypass their entire argument by only reviewing studies that show health effects at exposure levels of 500 uW/cm^2 or less--all the way down to .0000000026 uW/cm^2.

Contrary to general belief, this body of literature is consistent and not contradictory. Microwaves impact most obviously the nervous system and the heart. There is generally not a linear dose-response effect, and there is not a threshold below which there is no effect. An effect seen at low intensity will not necessarily be seen at high intensity, nor vice versa. Because the impact is cumulative, short-term experiments will not give the same results as long-term experiments. Often more than one type of effect will be seen in the same group of experimental subjects; therefore averaging the results may lose information. In light of all this, the kinds of studies that are doomed to obtain negative findings are those done at high intensities, short term, looking for thresholds and linear dose-responses, and averaging all their data. In this is consistency also.

Some of the early animal experiments have been criticized because metal objects near the animals may have distorted the field and increased their radiation dose beyond what was reported. However, the more recent work (since the mid 1970s)

has all been done in carefully shielded enclosures with no metal wires or objects, and has produced the same results. In any case, what we are trying to gauge here is the effect on human health, and none of us live in shielded houses devoid of wires or metal objects. The earliest research is therefore just as relevant to the human situation as the most recent, if not more so.

1. The nervous system

Radiation sickness. Symptoms that may occur include headache, fatigue, weakness, sleep disturbances, irritability, dizziness, memory difficulty, emotional instability, depression, anxiety, sexual disorders, skin markings, rash, burning sensation in the face, acrocyanosis (blue fingers and toes), sweating, tremors, accentuated tendon reflexes, decreased abdominal reflexes, unequal pupil size, and unstable pulse and blood pressure. These symptoms were consistently found in controlled studies of workers exposed to various frequencies of microwaves on the job, by:

Sadchikova (1960) in a clinical study of 525 workers exposed to microwave generating equipment. Those exposed to hundreds of microwatts per square centimeter or less had symptoms more often than those exposed to higher intensities.

Sadchikova (1974) in a clinical study of 1180 workers. Here too those exposed to lower intensities had more frequent symptoms than those exposed to higher intensities. Certain types of changes, for example hypotension and bradycardia, were more frequent at high intensities.

Klimkova-Deutschova (1974) in a clinical study of 530 workers from 29 places of employment.

Baranski and Edelwejn (1975) in a study of workers in the Military Institute of Aviation Medicine, Warsaw.

Zalyubovskaya and Kiselev (1978) in a clinical study of 72 engineers and technicians.

Bachurin (1979) in a clinical study of 100 television, radio, and other workers exposed to 20-60 uW/cm^2 and up to 100 uW/cm^2 on occasion. Photophobia was also noted in an occasional worker.

Sadchikova et al. (1980) in a clinical study of 50 industrial workers exposed to several hundred uW/cm^2.

Huai (1981) in a clinical study of 841 workers in 11 factories and institutes, including 238 people exposed to less than 50 uW/cm^2.

Gorbach (1982) in a clinical study of 142 workers exposed to microwave equipment.

Trinos (1982) in a clinical study of 2247 workers at 2 industrial plants.

Markarov et al. (1995), in a clinical study of 53 workers exposed to regular low-dose radiation.

Several cases of psychosis have been described in workers with objective signs of radiation sickness. These patients developed symptoms of mania and paranoia that did not fit the pattern for schizophrenia and were treatable only by removal from exposure to radio waves (Chudnovskiy et al. 1979).

Baranski and Czerski (1976) wrote, "The pathogenesis of these syndromes may be controversial but their existence cannot be denied. Similar observations were made by Miro in France, and in the United Kingdom and the United States, according to a personal communication made by Mumford to Seth and Michaelson" (p. 168).

Sensory thresholds. Bourgeois (1967), in an experiment with 36 young men 18-25 years of age, found that a two-minute exposure to 500 uW/cm^2 of 1000 MHz radiation significantly lowered their auditory threshold, i.e. made them more sensitive to sound. Both continuous and amplitude modulated waves had this effect.

Lobanova and Gordon (1960), in a clinical study of 358 workers 20-35 years of age occupationally exposed to low-level microwaves, found that a majority had either abnormally

high or, more often, abnormally low sensitivity to odors. A change in olfactory sensitivity was found to be one of the earliest signs of microwave influence.

Baranski and Czerski (1976) review several studies which show that chronic microwave exposure also decreases auditory, visual, and skin sensitivity, both clinically and in EEG studies.

EEG. Changes in the electroencephalogram show a generalized inhibition of the central nervous system as well as certain specific pathological patterns.

In addition to general inhibition, Klimkova-Deutschova (1974) found small but specific changes in the EEG of many workers exposed to microwaves in the 3-13 centimeter band. This included synchronized slow waves of high amplitude, similar to those seen in epileptic seizures. The EEG was said to be an important diagnostic tool that objectively shows microwave effects even when clinical signs are only slight.

Baranski and Edelwejn (1975) reported that workers with the longest occupational exposure to microwaves generally exhibit flat EEG recordings.

Huai (1981), in an examination of 106 microwave-exposed workers, found an increase in slow (theta and delta) waves on their EEG.

Mann and Roschke (1996) exposed 14 healthy male volunteers 21-34 years of age to a digital cellular phone during the night at a distance of 40 cm., so that the power density reaching their head was 50 uW/cm^2. Specific alterations in their EEG were noted. The radiation also caused a significant decrease in the amount of REM sleep.

Sikorski and Bielski (1996) found abnormal glucose tolerance tests in 31 of 50 workers exposed to radio waves. Of these, 10 also had abnormal EEGs.

Experiments on animals. Acute low-level exposure to microwaves stimulates the nervous system, while chronic exposure suppresses it. This has been confirmed in animals by behavioral changes, EEG changes, lowered levels of neurotransmitters, lowered levels of the respiratory enzyme cytochrome oxidase, and cell damage as seen in the electron microscope.

Gvozdikova et al. (1964) exposed groups of chinchilla rabbits to 12.5 cm., 52 cm., and 1 m. radiation for 5 minutes. 81% showed changes in the EEG when exposed to 20 uW/cm^2.

Frey (1967) induced evoked potentials in the brain stem of cats with pulsed 1200-1525 MHz waves at an average power density of 30 uW/cm^2.

Giarola et al. (1971) observed a tranquilizing effect on chickens and rats at 24 uW/cm^2 using 880 MHz waves.

Dumanskij and Shandala (1974) irradiated 228 white rats and 60 rabbits, 8-12 hours a day for 120 days. Inhibition of conditioned reflexes was produced by 6 meter waves at 1.9 uW/cm^2, and by 3 centimeter waves at 5 uW/cm^2. Definite EEG changes were noted even at 0.06 uW/cm^2 for the 6 meter waves: an initial excitation of the nervous system gave way to synchronized rhythms and then to general inhibition during the course of the experiment. "Electromagnetic energy in the UHF range and 0.06-10 uW/cm^2 intensity . . . was indeed active biologically according to the results of statistical analysis" (p. 291). Other indicators of nervous system activity--cholinesterase and sulfhydryl groups in the blood--were also significantly lowered at 1.9 uW/cm^2.

Gabovich et al. (1979) found that 100 uW/cm^2 for 2 hours a day first increased the work capacity of rats and later decreased it. It also affected the latent period of unconditioned reflexes, altered sleep, and lowered cholinesterase activity in the blood and the brain. The frequency was 2375 MHz, continuous mode.

Grin' (1978) found that 50 uW/cm^2 increased epinephrine, norepinephrine, and dopamine in the brain of rats after 7 hours a day exposure for a month. The wavelength was 12.6 cm. 500 uW/cm^2 decreased the levels, and exhausted the adreno-sympathetic system.

Dumanskiy and Tomashevskaya (1978) found a 20-26% decrease in cytochrome oxidase, a respiratory enzyme, in brain mitochondria, after 4 months exposure of rats. The frequency was 2375 MHz, continuous wave, and the power was 100 uW/cm^2. Another enzyme, glucose-6-phosphate dehydrogenase (G-6-PDH), rose 20-28% in compensation.

In a 4-month experiment with 1200 albino rats, Dumanskiy et al. (1982) found an increased skin sensitivity to electrical stimulation, decreased work capacity and altered conditioned reflexes at 25-60 uW/cm^2. 40 uW/cm^2 activated blood cholinesterase, while 115 uW/cm^2 inhibited the enzyme. The wavelength was 3 cm.

Shandala et al. (1979) exposed rabbits to 2375 MHz waves for 7 hours a day for 3 months. 10 uW/cm^2 stimulated the electrical activity of the brain. 50 uW/cm^2 stimulated brain activity for 30 days, then gradually inhibited it. At 500 uW/cm^2 inhibition began within 2 weeks. In rats, 500 uW/cm^2 decreased behavioral search activity, suppressed the food response, and decreased work capacity. 10 uW/cm^2 and 50 uW/cm^2 had the same suppressive effect on the nervous system after 30 days, and increased the sensitivity of the skin to electrical irritation.

Shutenko et al. (1981) exposed rats to 2375 MHz waves for 2 hours a day for 10 weeks. 10 uW/cm^2 inhibited unconditioned reflexes, and lowered cholinesterase in blood and brain tissue.

Belokrinitskiy (1982a) found an increase in the activity of the enzymes succinate dehydrogenase (SDH), malate dehydrogenase (MDH), lactate dehydrogenase (LDH), and G-6-PDH,

and a decrease in levels of glycogen and RNA in the cells of the brain and other organs of rats after chronic exposure to 5 uW/cm^2, and after a single 3-hour exposure to 50 uW/cm^2. Two months of exposure to 10 uW/cm^2 damaged the mitochondria, the endoplasmic reticulum, and the nucleus of cells. These changes did not revert to normal within one month. 1000 uW/cm^2 produced much more drastic cell changes. 10 mW/cm^2 (supposedly "non-thermal" and safe!) swelled cells, altered their shape, damaged blood vessels, demyelinized nerve fibers, etc., after just one hour exposure of cats. The wavelength was 12.6 cm.

In another experiment, Belokrinitskiy (1982b) found damaged neurofibrils and disappearance of the myelin sheath in the hippocampus of rats even at 50 uW/cm^2.

Frey (1988) inhibited aggressive behavior in rats at 50 uW/cm^2, and modified stereotypic behavior at 8 uW/cm^2. Certain odors modified this last effect. 200 uW/cm^2 enhanced the narcotic effect of morphine.

Kunjilwar and Behari (1993) measured a significant decrease in acetylcholinesterase activity in the brain of rats after exposure to several frequencies of modulated radio waves at 250 uW/cm^2 for 3 hours a day for a month.

Tarricone et al. (1993) exposed quail embryo cells to 10.75 GHz waves at a few uW/cm^2, and demonstrated changes in the acetylcholine receptor channels.

Chizhenkova and Safroshkina (1993) exposed rabbits to 800 MHz continuous waves for one minute while monitoring cortical neuron activity in the brain. 100-500 uW/cm^2 decreased the frequency of spike bursts, and increased the number of spikes in a burst of neuronal discharges.

Kolomytkin (1994) showed that a 5-minute exposure of rats to 915 MHz waves modulated at 16 Hz increased the excitation of the brain by increasing the binding of glutamate and decreasing the binding of GABA to synaptic membranes. This occurred at less than 50 uW/cm^2.

Navakatikian and Tomashevskaya (1994) exposed rats to 3000 MHz pulsed radiation. Half an hour of exposure to 10 uW/cm^2 stimulated conditioned behavior, while 12 hours inhibited the behavior.

Epidemiological studies. Chiang et al. (1989) surveyed 1170 people living and working near radio antennas and radar installations in China. Those exposed to more than 10 uW/cm^2 scored worse on a memory test, and had increased visual reaction time, compared to unexposed controls.

In the early 1990s, the Swiss government commissioned a survey of 215 people living near a short wave transmitter (Abelin et al., 1995). They kept diaries. Those living less than 1.5 kilometers from the transmitter had more sleeping problems, headaches, tiredness, irritability, low-back ache and limb pain than those living over 4 kilometers away. Fewer children were promoted from primary to secondary schools. Sleep disorders were correlated with distance from the station, and improved one day after a shutdown of the transmitter. Average exposure levels were as little as 54 nW/cm^2 (.054 uW/cm^2).

An ongoing study near a radar station in Skrunda, Latvia (Kolodynski and Kolodynska 1996) has found impaired motor function, reaction time, memory and attention among school children who live in exposed areas as compared with those who live in unexposed areas. 966 children have been tested. Levels of exposure are generally below 0.1 uW/cm^2 and at no homes does the power density exceed 10 uW/cm^2.

Other reviews of nervous system effects can be found in Frey (1965, 1994), Marha (1969, 1971), Healer (1969), Dodge (1969), Bawin and Medici (1973), Gordon **et al.** (1974), Baranski and Czerski (1976), Solon (1979), McRee (1979, 1980), Huai (1981), Medici (1982), Glaser and Dodge (1982), Ray and Behari (1990), and Kunjilwar and Behari (1993).

2. The heart

Radiation sickness typically causes bradycardia (slow heartbeat) and hypotension (low blood pressure), which are warning signs. Orlova (1960) describes other typical symptoms: tingling in the region of the heart, palpitations, stabbing pains in the heart region, and shortness of breath after exertion. Other physical findings may include an increase in the limits of the heart to the left, thudding sounds, systolic murmurs, and changes in the EKG: bradycardia or tachycardia, sinus arrhythmia, lengthened conduction, and decrease in spike amplitudes, especially in a stress test. In a clinical study of 525 workers, this researcher found cardiac symptoms in 22.3% of even the least exposed group, compared to 10% of unexposed controls. Objective cardiac changes were found in 18-35%, depending on length of time worked, compared to 9% of unexposed workers.

Other authors report similar findings. See Dodge (1969) for a review. Bachurin (1979), on EKG, found left axis deviation, sinus tachycardia or bradycardia, disturbances of intraventricular conduction, and signs of myocardial hypoxia.

Zmyslony et al. (1996) found that AM broadcast workers had six times the risk for EKG disturbances compared to radio link station workers not exposed to radio waves.

Baranski and Czerski (1976) note a change in the velocity of the pulse wave.

Huai (1981) found hypotension gave way to hypertension after 3-6 years of exposure.

Sadchikova (1960, 1974, 1980) also found a weakening of the orthostatic reflex. In advanced stages of the disease there were crises of cerebral and coronary insufficiency, and the clinical picture of ischaemic heart disease and hypertension developed.

Animal studies. Levitina (1966) irradiated live frogs with 12.5 cm continuous waves at an intensity of 30-60 uW/cm^2. Illuminating the frog's back slowed its heart rate in most

cases, while illuminating only the back of its head quickened its heart rate. When the frog was anesthetized, no effect was found. Similar results were found in experiments done previously at higher intensities in rabbits (Presman and Levitina 1962a,b).

Serkyuk exposed rabbits to 2375 MHz waves for 60 days. Exposure to 0.06 uW/cm^2 caused slowing of the heart rate and changes in the EKG (McRee 1980).

Frey and Seifert (1968) showed that the heart is most vulnerable to microwaves at particular times during its rhythm. They illuminated frog hearts with pulsed 1425 MHz waves at an average power density of 0.6 uW/cm^2. When the heart was illuminated with a pulse 200 milliseconds after the P wave, the beat rate increased. In half the cases arrhythmias occurred. Occasionally the heart stopped. Later experiments found a similar effect with live frogs at 3 uW/cm^2 (Frey 1988).

See Frey (1988) for a good review of other research.

3. Cancer

Good research on microwave cancer is sparser but fairly conclusive.

Guy and Kung exposed 200 rats to pulsed 2450 MHz waves at 480 uW/cm^2 for 23 hours a day. They developed two and a half times as many cancers over their lifetime under normal life conditions as 200 unexposed controls (discussed in Frey 1994 and Szmigielski 1989a,b).

Balcer-Kubiczek (1994) proved microwaves are carcinogenic by using the C3H/10T1/2 mouse embryo cell line. This cell line is frequently used in cancer research to identify chemical carcinogens. 2450 MHz pulsed waves were used. When irradiation was followed by treatment with a known tumor promoter, TPA, it caused cancers in a dose-response relationship, similar to that seen with ionizing radiation. TPA by itself did not cause any tumors. This author concludes that "2.45 GHz microwaves seem to act as an

initiator or carcinogen, rather than as a promoter of malignant transformation" (p. 150). 0.1 W/kg was effective.

Several epidemiological surveys have been combined with field measurements of radiation levels. In Honolulu, which has the highest radiation levels of any U.S. urban area (Microwave News, Jan./Feb. 1985), the State Health Department compared the cancer incidence of nine census tracts that include broadcast towers with that of two demographically similar tracts that do not. The U.S. Environmental Protection Agency measured radiofrequency intensities, which were below 100 uW/cm^2 almost everywhere in the exposed tracts. Cancer, and especially leukemia, was significantly more common in the tracts with towers (Goldsmith 1995, 1996, Marino 1988).

Hocking and Gordon (1995) report on a similar study in Sydney, Australia. They compared cancer incidence and mortality from 1972-1990 in six northern Sydney municipalities, three of which immediately surround transmitters for 4 TV stations and an FM radio station, and three of which are more distant. Exposed children had double the rate of leukemia compared to children in the unexposed communities. Radio wave intensity was 0.2-8.0 uW/cm^2 near the towers, and 0.02 uW/cm^2 in the distant communities.

Dr. William Morton of the University of Oregon's Health Sciences Center in Portland has found similar trends in his study of cancer and broadcast radiation in Portland, where levels in excess of 100 uW/cm^2 occur in some public areas and in private homes (Marino 1988, Microwave News, Nov./Dec. 1995).

Szmigielski (1996) did a controlled retrospective study of cancer incidence in all Polish military career personnel from 1971 to 1985. This included on average 128,000 persons per year. Personnel exposed to microwaves (generally less than 200 uW/cm^2) had more than double the cancer rate of everybody else. Leukemia was more than eight times as common.

For reviews of other research, see Frey (1994), Szmigielski (1988, 1989a,b), Savitz (1987), and Goldsmith (1995, 1996).

4. Reproduction

Even extremely low levels of microwaves can cause miscarriage, altered sex ratios, birth defects, and other effects on reproduction.

Ouellet-Hellstrom and Stewart (1993) did a case-control study of over 6600 pregnancies among female members of the American Physical Therapy Association. Those who administered microwave diathermy in the six months prior to or during their pregnancy had more than three times as many early miscarriages as unexposed therapists. The risk increased with increasing numbers of exposures.

Huai (1979) found abnormal menstruation three times as often in microwave-exposed workers as in unexposed workers.

The ongoing study in Latvia has found up to 25% fewer boys in certain school grades in the area that has been exposed to the radar since 1971 (Kolodynski and Kolodynska 1996).

Navakatikian and Tomashevskaya (1994) found a decrease in testosterone in rats exposed to pulsed or continuous 2450 MHz waves at an intensity of 100 uW/cm^2. They review a study by Mikolaichyk which found changes in FSH and LH in the hypothalamus of rats from a single exposure to 10 uW/cm^2.

Krueger and Giarola (1975) exposed laying hens to 260 MHz waves for 16 weeks at an intensity of 5-125 uW/cm^2. Egg production was 20% less, a greater percentage of females were hatched, and egg shell quality deteriorated.

Bigu Del Blanco et al. (1973) found a 14% increase in egg production by hens exposed to continuous 7 GHz waves at